NanoVNA

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- What is it?
- Where can you get it?
- What can you do with it?
- Supporting PC Software (NanoSaver)
- Practical examples

NOTE: This is not a full tutorial. It’s intended to demonstrate many of the capabilities of the NanoVNA

Disclaimer

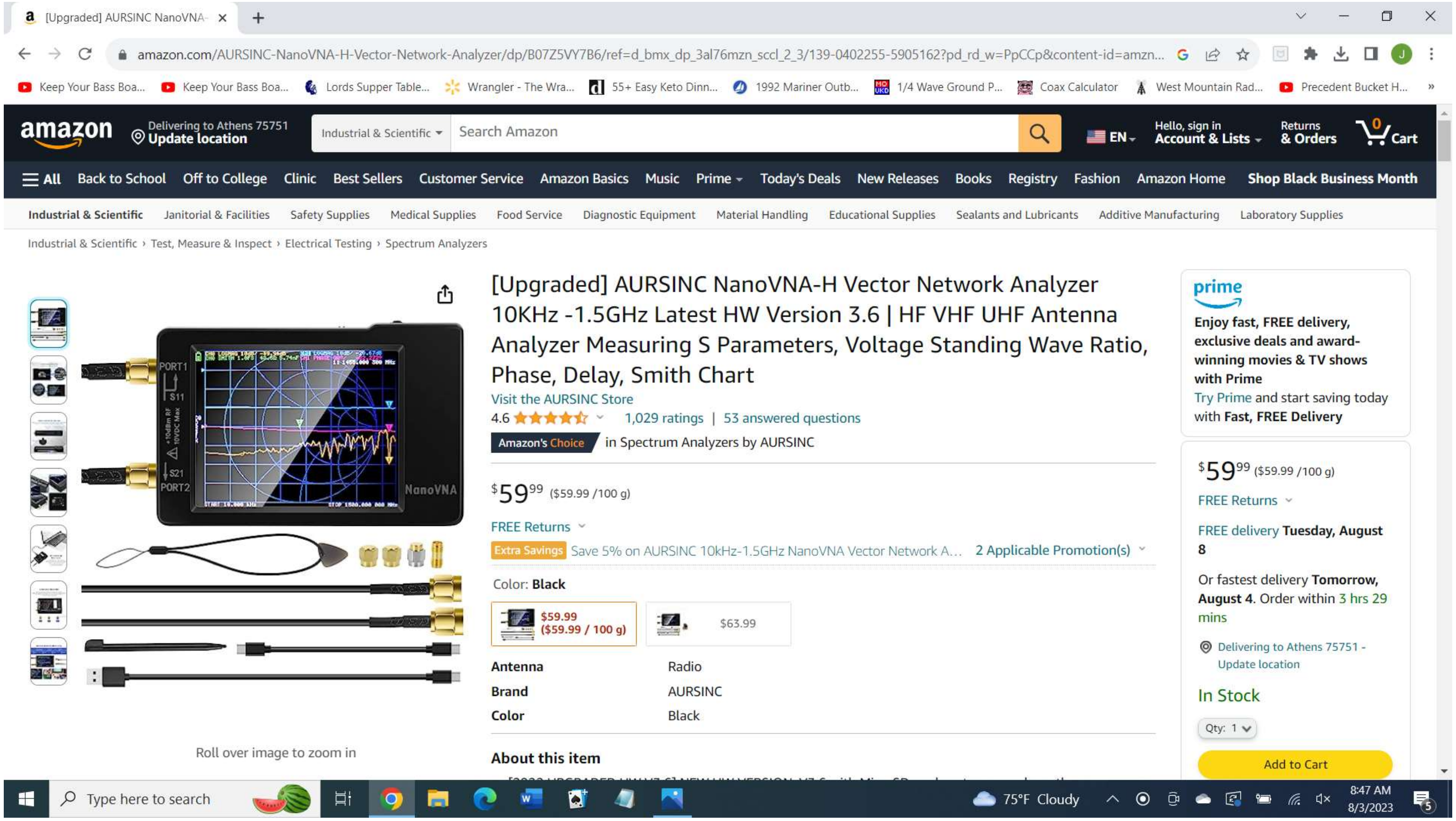
I’m not an experienced Ham operator and my background is digital electronics. I understand “1’s” and “0’s. I love experimenting but have lesser understanding of HF analog circuits. They are “magic” to me, so please bear with me as I go through this presentation. Any comments are welcome and encouraged.

What is the NanoVNA?

Instrument used to analyze the behavior of various analog systems over a range of frequencies (more on this later)

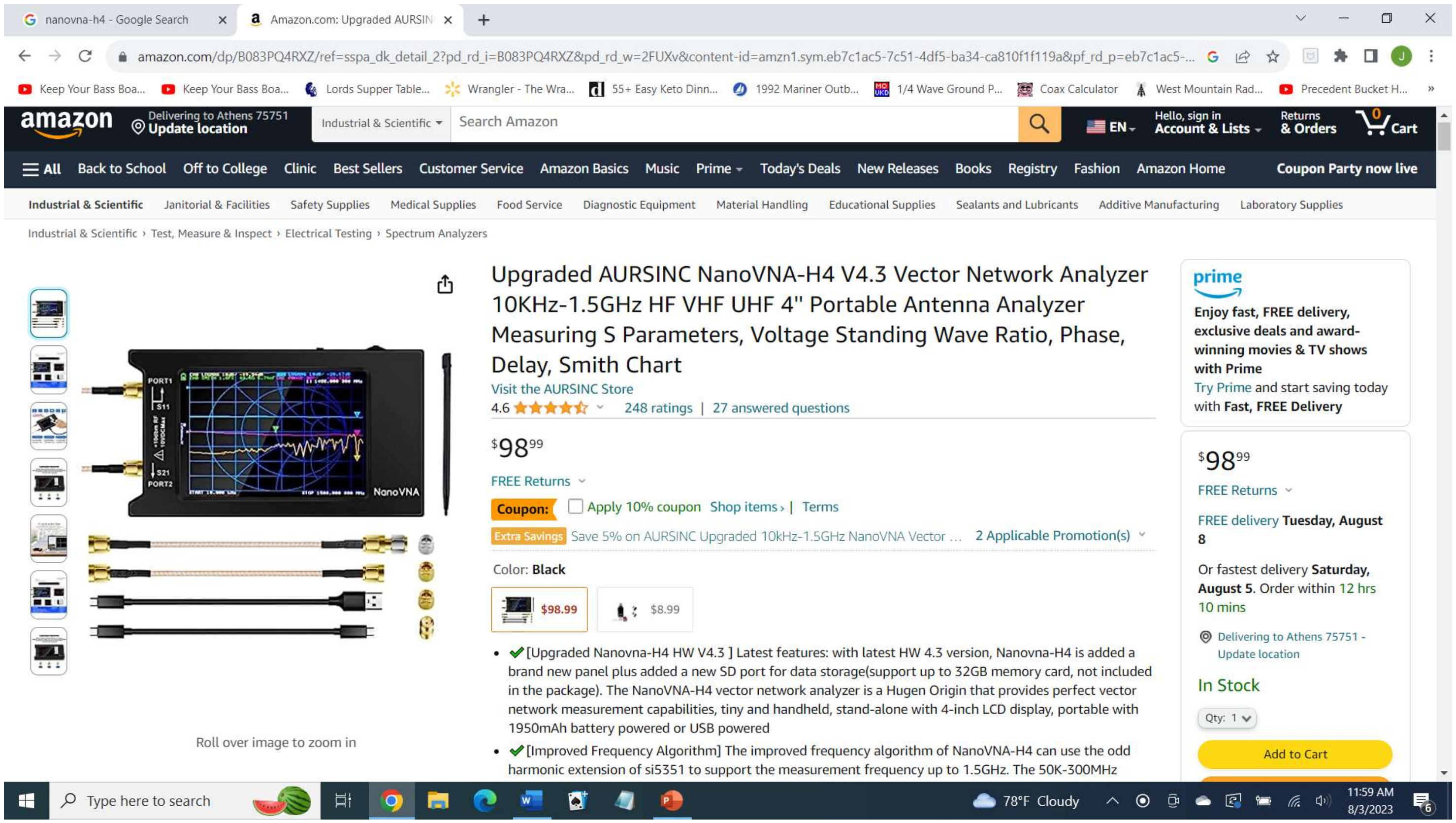
- Sweep Range: 50kHz to 1500 mHz
  - Uses the si5351 clock generator to provide direct output in the 50KHz-300MHz frequency range
  - The 3^{rd} harmonic is used for the 300MHz-900MHz band
  - The 5^{th} harmonic is used 900MHz-1.5GHz band
- Display: 2.8" TFT (320x240) or 4" TFT (320x480) Touch Screen
- 101 measurement points (screen resolution)
- Interface: USB > USB type C
- RF output: -13dBm (50nW)
- Accuracy: <0.5ppm
- Scanning Points: 101 (fixed)
- Display Tracking: 4
- Display Marking - 4
- Setting Save – 5

Where can you get the NanoVNA?



2.3” version of the newer Hugen design instead of original edy555 design

Where can you get the NanoVNA?

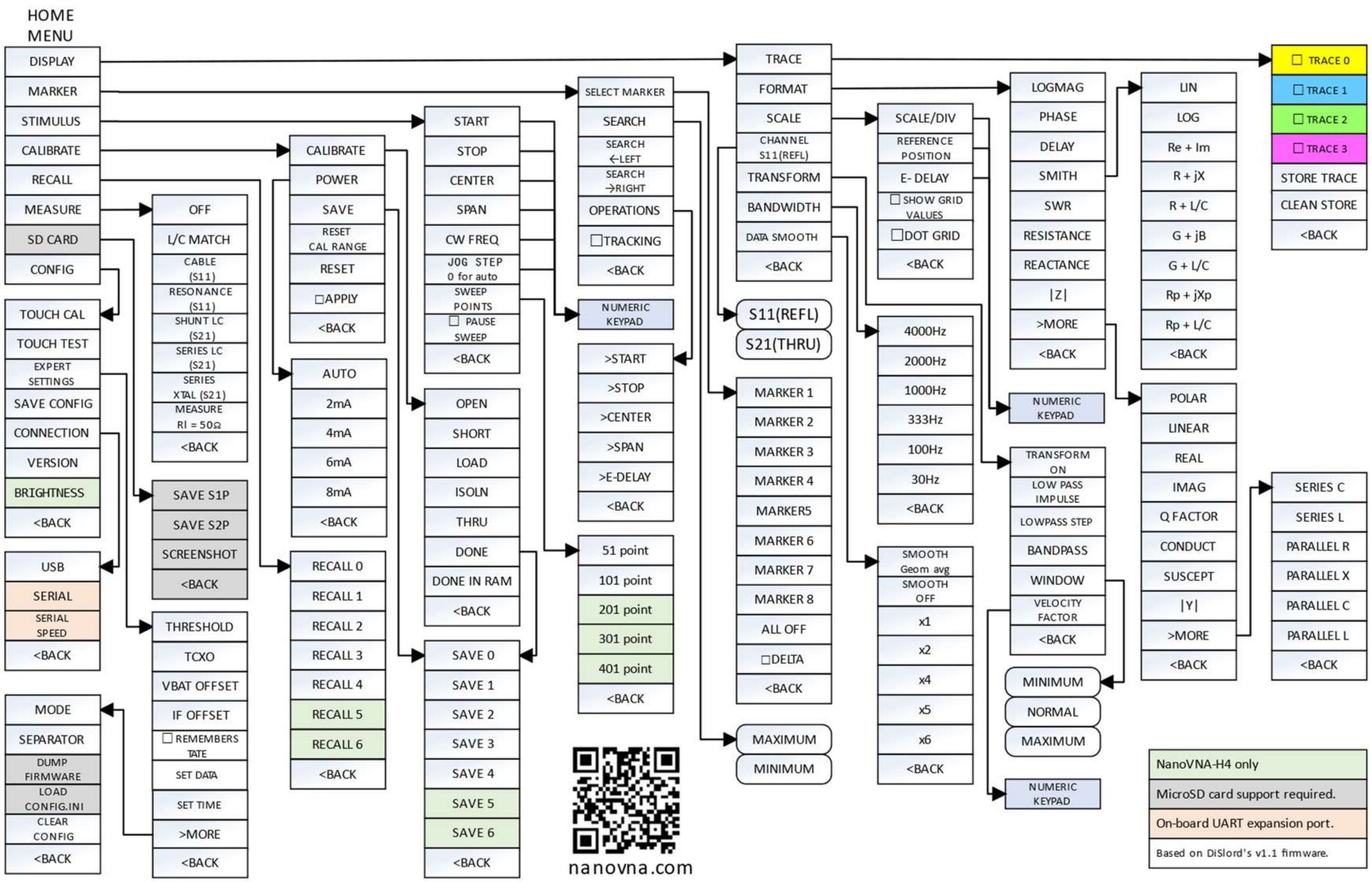


4” version of the newer Hugen design instead of original edy555 design

What can you do with the NanoVNA?

- Measure the performance of an antenna system (bandwidth, SWR, impedance, Return Loss more)
- Measure the length of a piece of coax (Got any bundles of coax laying around?)
- Find fault point in coax
- Measure inductance or capacitance (Who doesn't have a junk box of assorted coils and capacitors?)
- Measure performance of a low pass filter, notch filter, balun, unun, etc
- Measure insertion loss of a circuit

NanoVNA Menu Structure Map



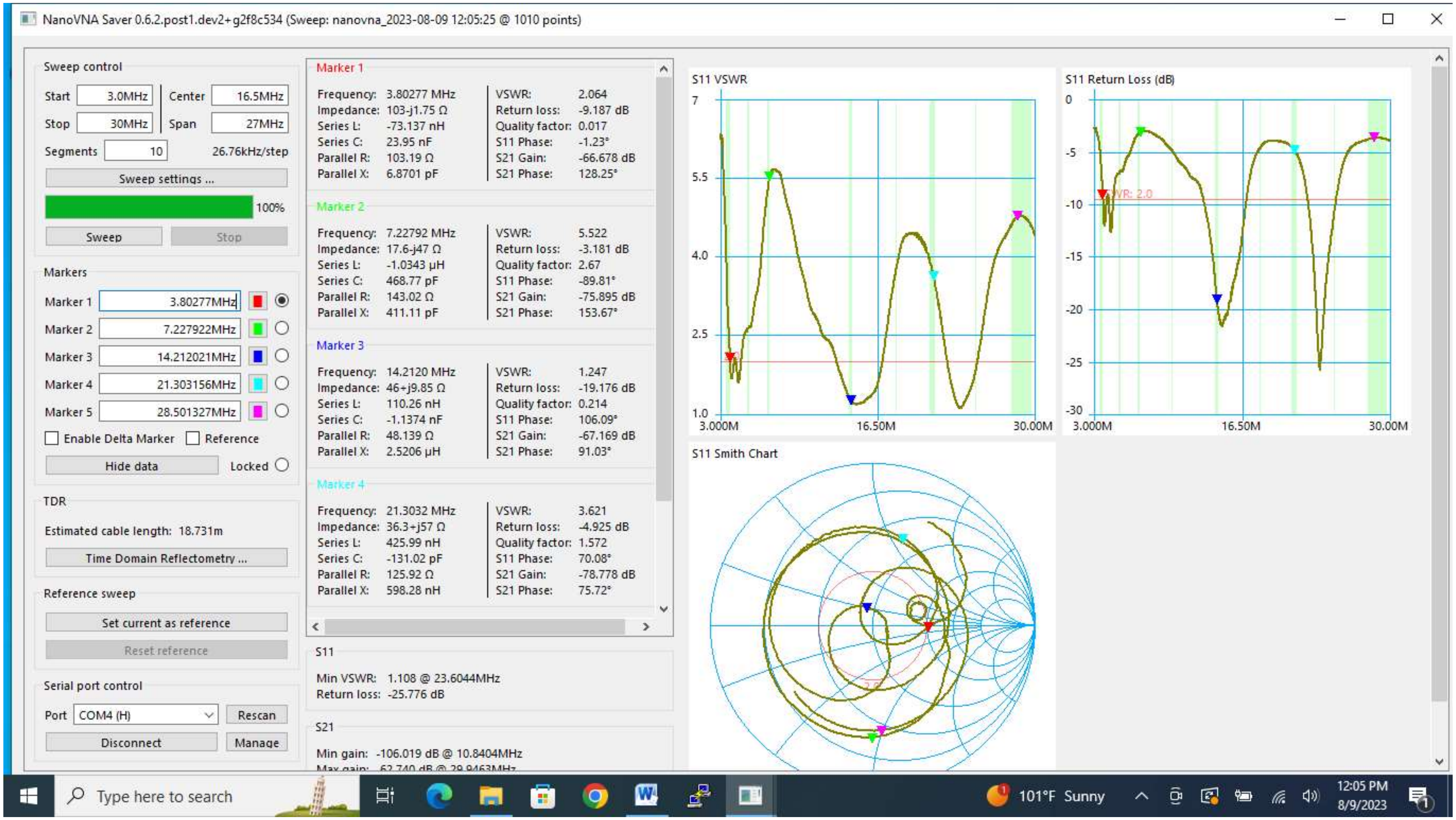
NanoVNA-saver software

Free Download from: https://github.com/NanoVNA-Saver/nanovna-saver/releases/tag/v0.6.2
Download the PC file: NanoVNASaver.win.x64.zip

Current features

- Operate and read data from a NanoVNA, uses only raw data from NanoVNA and does calculations
- Splitting a frequency range into multiple segments to increase resolution (tried up to >10k points)
- Averaging data for better results particularly at higher frequencies
- Displaying data on multiple chart types, (Smith, LogMag, Phase and VSWR-charts, for S11 and S21)
- Displaying markers for impedance, VSWR, Q, equivalent capacitance/inductance etc. at locations
- Displaying customizable frequency bands as reference, for example amateur radio bands
- Exporting and importing 1-port and 2-port Touchstone files
- TDR function (measurement of cable length) - including impedance display
- Filter analysis functions for low-pass, high-pass, band-pass and band-stop filters
- Display of both an active and a reference trace
- Live updates of data from the NanoVNA, including for multi-segment sweeps
- In-application calibration, including compensation for non-ideal calibration standards
- Customizable display options, including "dark mode"
- Exporting images of plotted values

Sample of my Random Wire Antenna NanoVNA-Saver display



Important: Before measurements, you need to calibrate for the setup you're using to get the most accurate results

Calibration involves the following steps from the NanoVNA menu:

1. Set the sweep range you plan to operate over
2. Measure 3 points on CH0 using the standards that come with the NanoVNA (Open, Short, 50 Ohm load)
3. Measure the isolation on CH1 using the 50 Ohm load
4. Measure the through measurement between CH0 and CH1
5. Save the results
6. Note NanoVNA-Saver has its own calibration function but performs it similarly.

Warning: Antenna static can damage NanoVNA

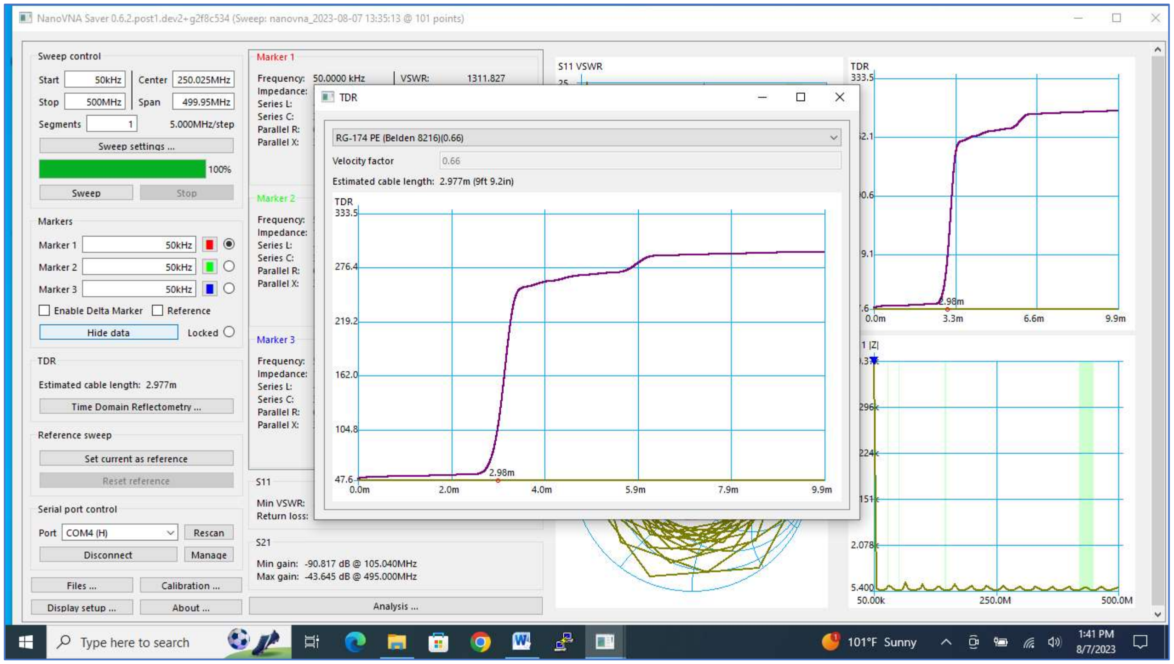
For the first test, let’s measure some coax length.

My cable length extension is 10 feet or 3 meters and it appears to be RG174 cable which has a published velocity factor of 66%. We can use the NanoVNA to measure TDR and get a pretty accurate cable measurement.

NanoVNA-Saver gave a length of 2.966m

The NanoVNA itself has two ways to measure:

1. There is a cable measurement function accessed from the Menu – MEASURE>CABLE giving a measurement of 2.937m
2. I saved a setup from YouTube in RECALL1 and it measured 2.937m

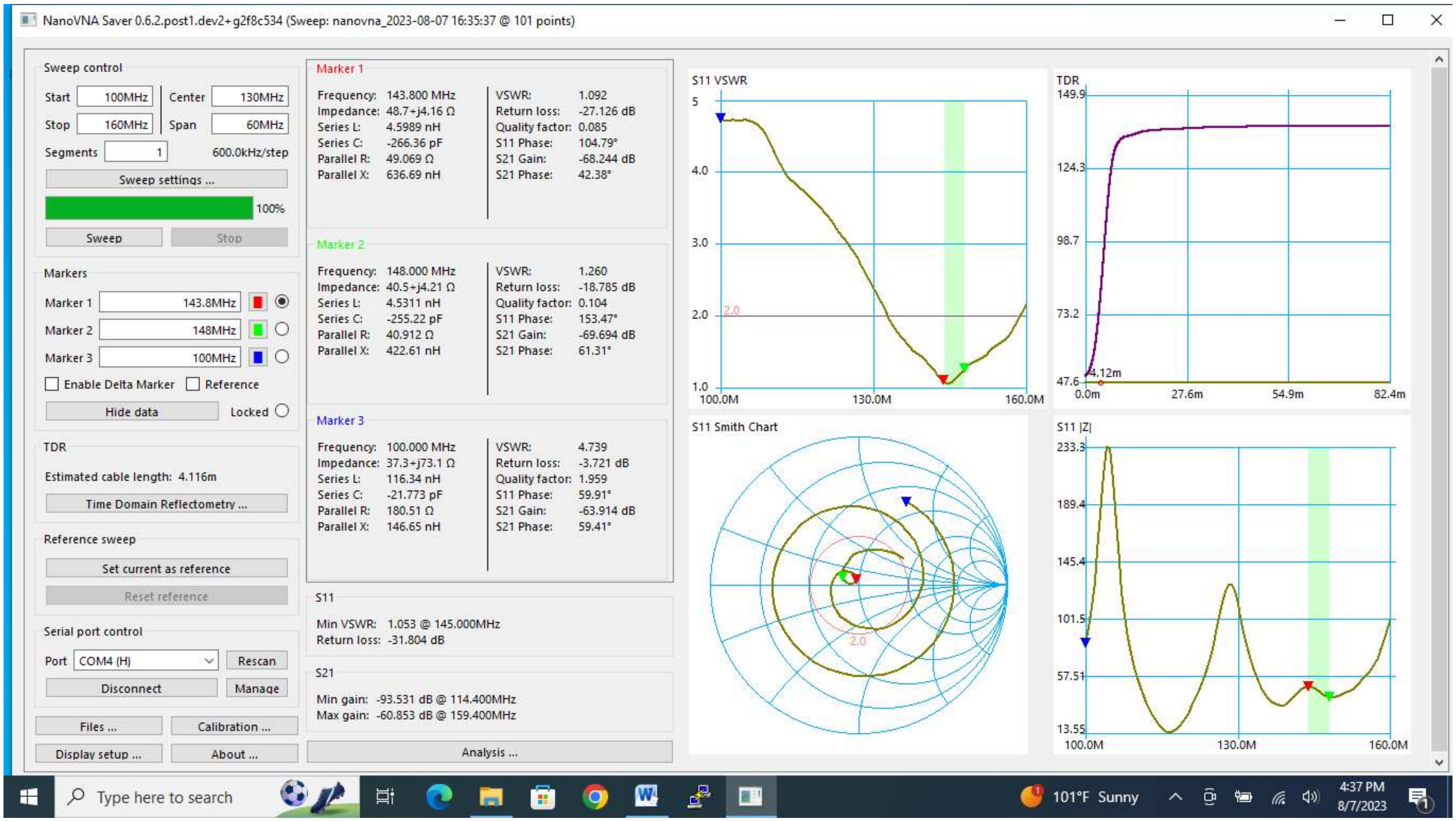


Why is there a difference in measurement? From what I understand, each uses a different measurement approach. Which is better? All are within 2% of the actual.

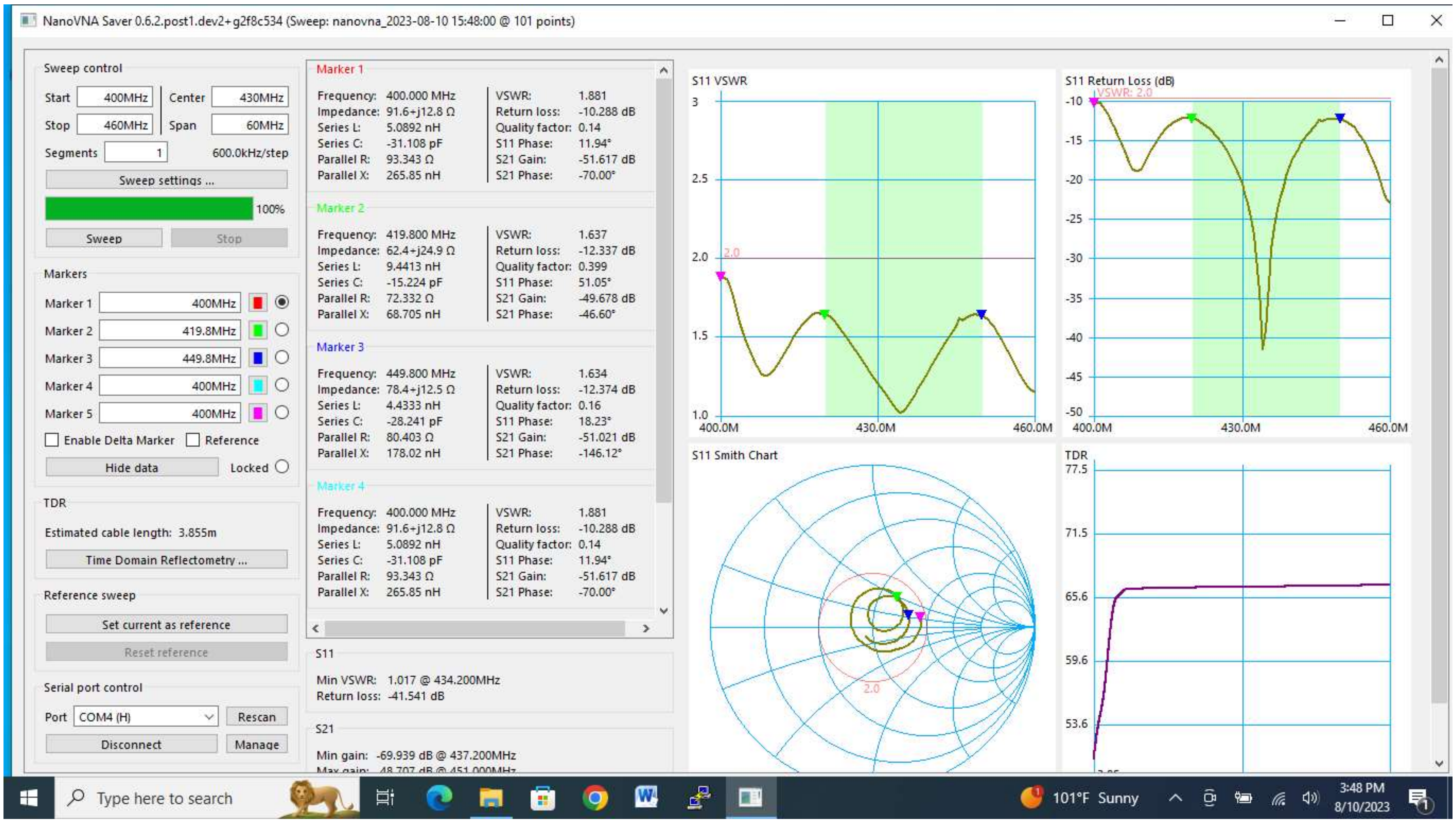
Measuring various aspects of a VHF Dipole Antenna System

1. Use CH0 (S11) Port to scan VHF Band (144 to 148 MHz)
2. Remember to calibrate, especially at higher frequencies that are more sensitive to setup
3. Adjust Dipole length to about ½ wavelength, 50 cm each side
4. Examine SWR, impedance and return loss
5. Use NanoVNA-Saver to get a better view of the sweep
6. How does this antenna perform on 70 cm (420-450 MHz)?

2m band sweep of the 1/2wave 2m dipole antenna system



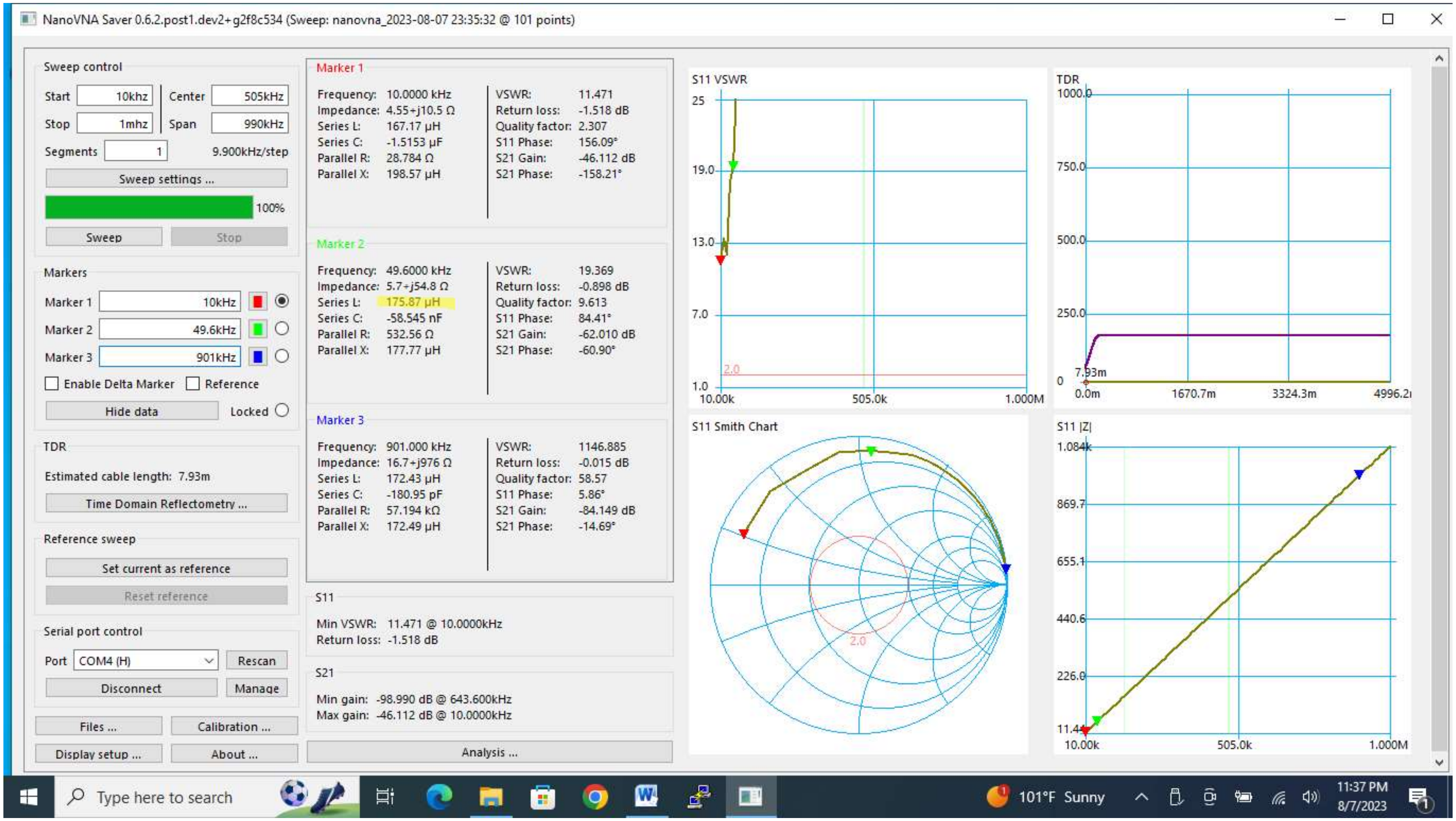
70cm band sweep of the 1/2wave 2m dipole antenna system



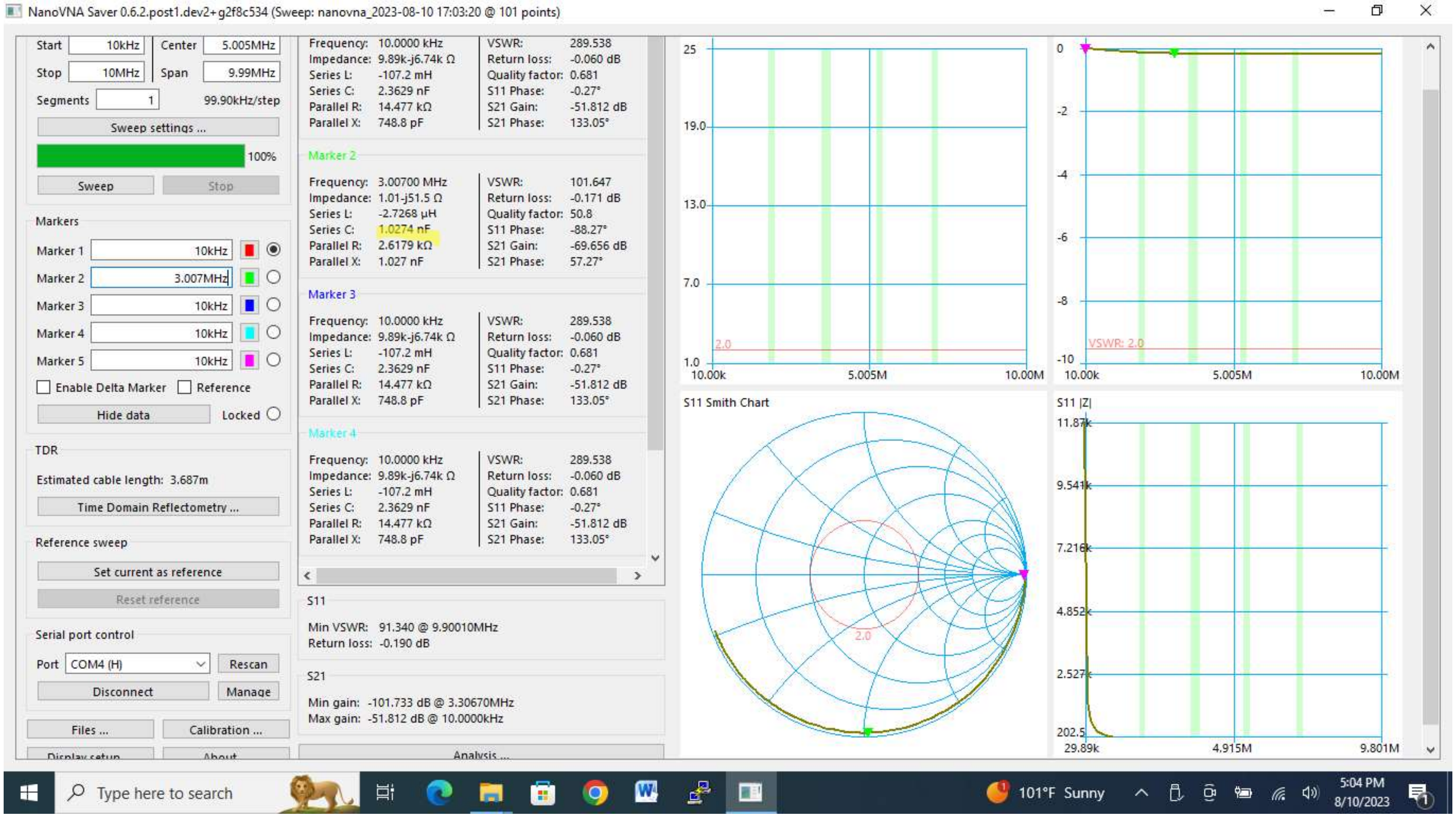
How to measure the value of an inductor or capacitor

1. Use CH0 (S11) to scan a frequency range
2. What happens to inductors and capacitors as you increase frequency?
3. Use a lower frequency range to determine the value
4. I’ll use a sweep of 10 KHz to 1 MHz. You can adjust the sweep range as needed for your component.
5. Another question. Where on the Smith Chart is the highest inductance, highest capacitance?
6. Let’s measure an inductor and a capacitor with the NanoVNA and NanoVNA-Saver…

Measured value of a 180 uH inductor



Measured value of a 1000 pF capacitor



Measuring Performance of Low Pass Filters

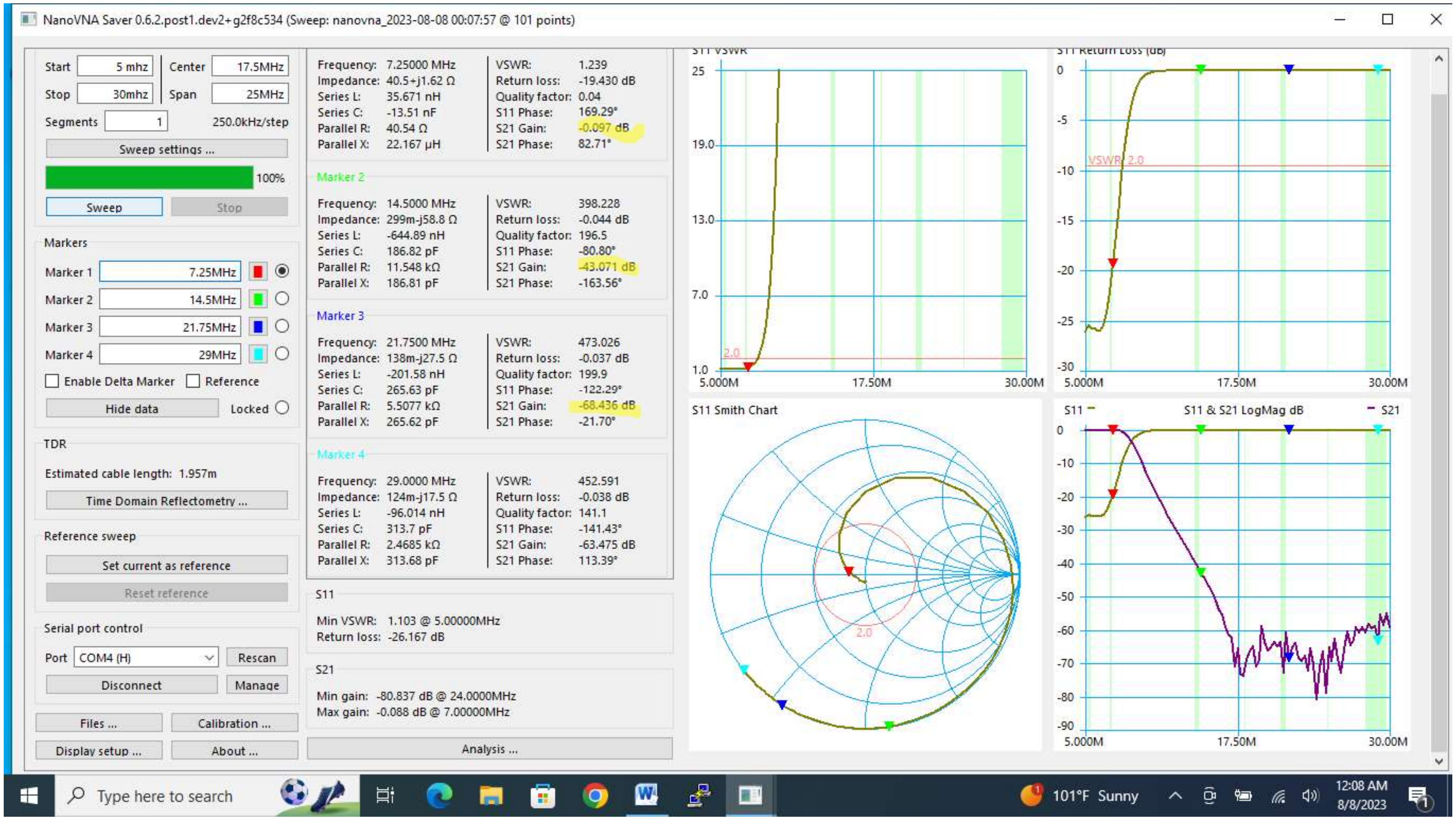
1. We need to use CH0 (S11) for output to the filter and CH1 (S21) for input from the filter
2. We can sweep the desired frequency rangy range, i.e. various ham bands
3. Set Markers at the fundamental frequency desired and 2^{nd} harmonic, and 3^{rd} harmonic
4. Question: What is FCC requirement for attenuation of 2^{nd} harmonic of a frequency below fundamental emission?
5. Let's look at the performance of a 40m, 7 element Chebyshev Filter
6. After that, we'll look at a multiband, relay switched, 5 element Chebyshev Filter

§97.307 Emission standards.

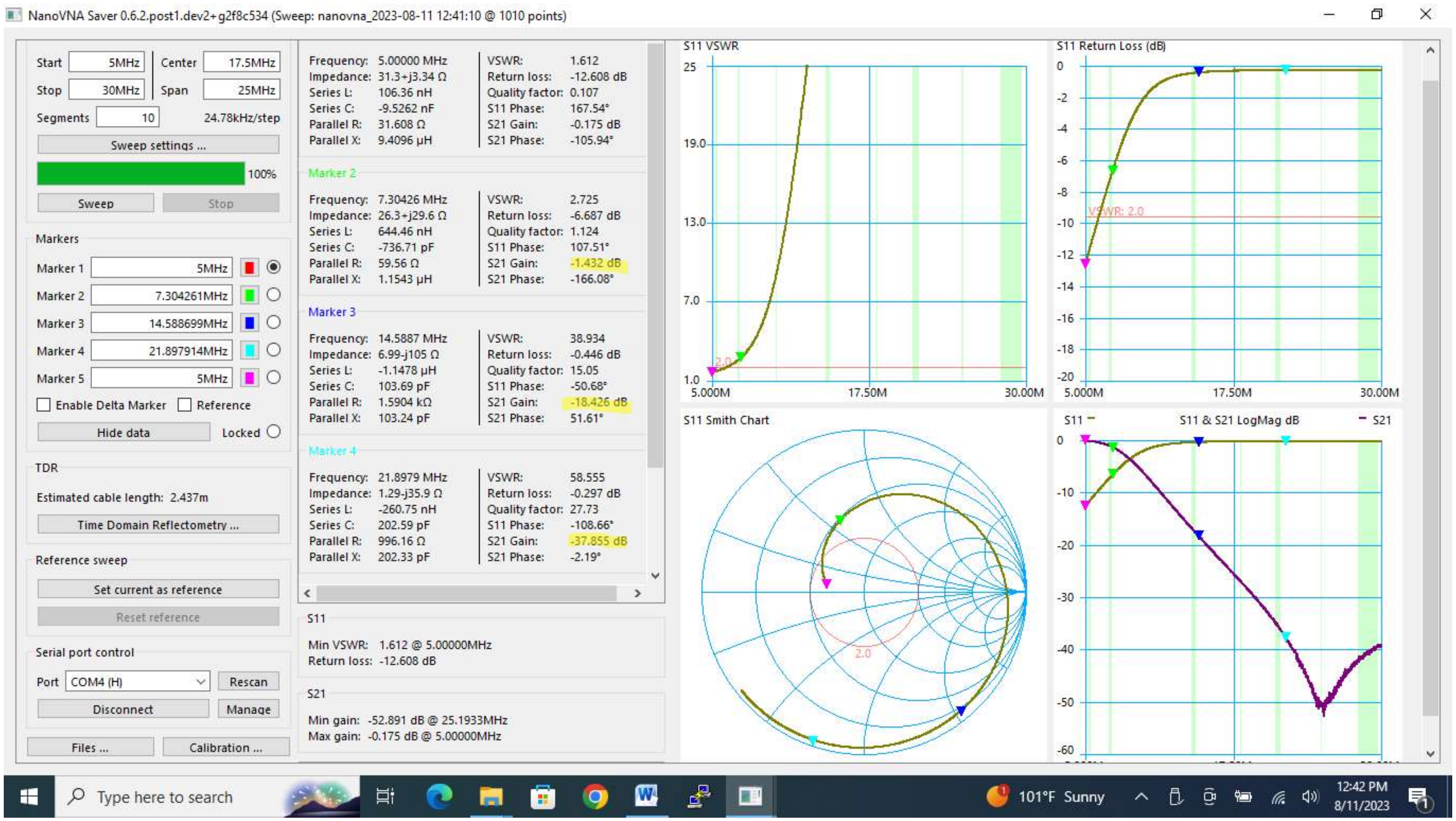
...

(d) For transmitters installed after January 1, 2003, the mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency below 30 MHz must be at least 43 dB below the mean power of the fundamental emission. For transmitters installed on or before January 1, 2003, the mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency below 30 MHz must not exceed 50 mW and must be at least 40 dB below the mean power of the fundamental emission. For a transmitter of mean power less than 5 W installed on or before January 1, 2003, the attenuation must be at least 30 dB. A transmitter built before April 15, 1977, or first marketed before January 1, 1978, is exempt from this requirement.

Measurement of 40m, 7-element Chebyshev low pass filter



Measurement of 40m, 5-element Chebyshev low pass filter



YouTube Videos of if interest

How to measure coax length:
https://www.youtube.com/watch?v=9thbTC8-JtA

How to evaluate an antenna system:
https://www.youtube.com/watch?v=xa6dqx9udcg

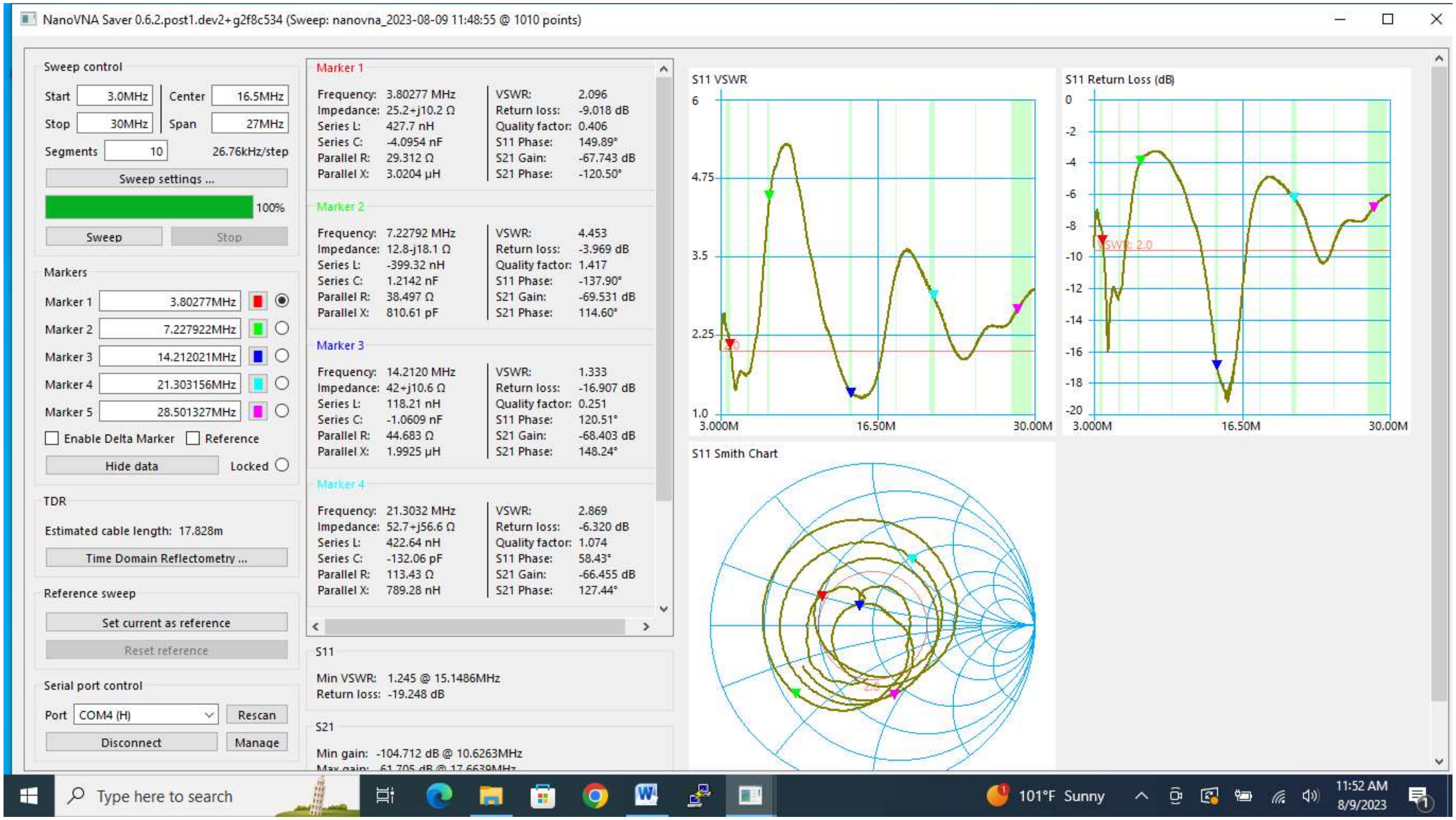
How to measure the value of inductors, capacitors:
https://www.youtube.com/watch?v=Pti8Erw_Kkg

How to measure the performance of a low pass filter:
https://www.youtube.com/watch?v=F17mN5uuzGY

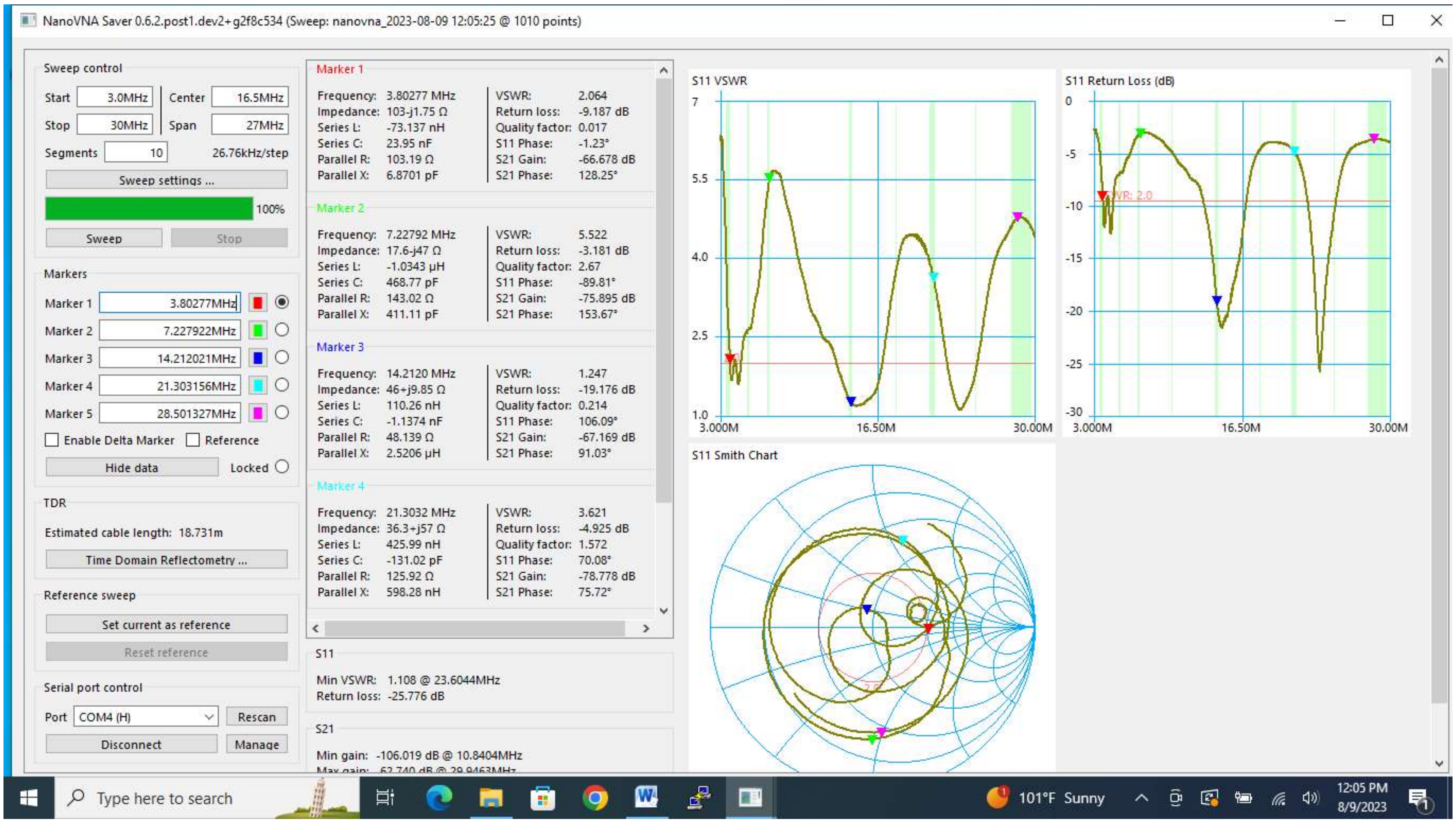
Velocity factor calculation:
https://www.youtube.com/watch?v=aWvPB299U60

BACKUP SLIDES

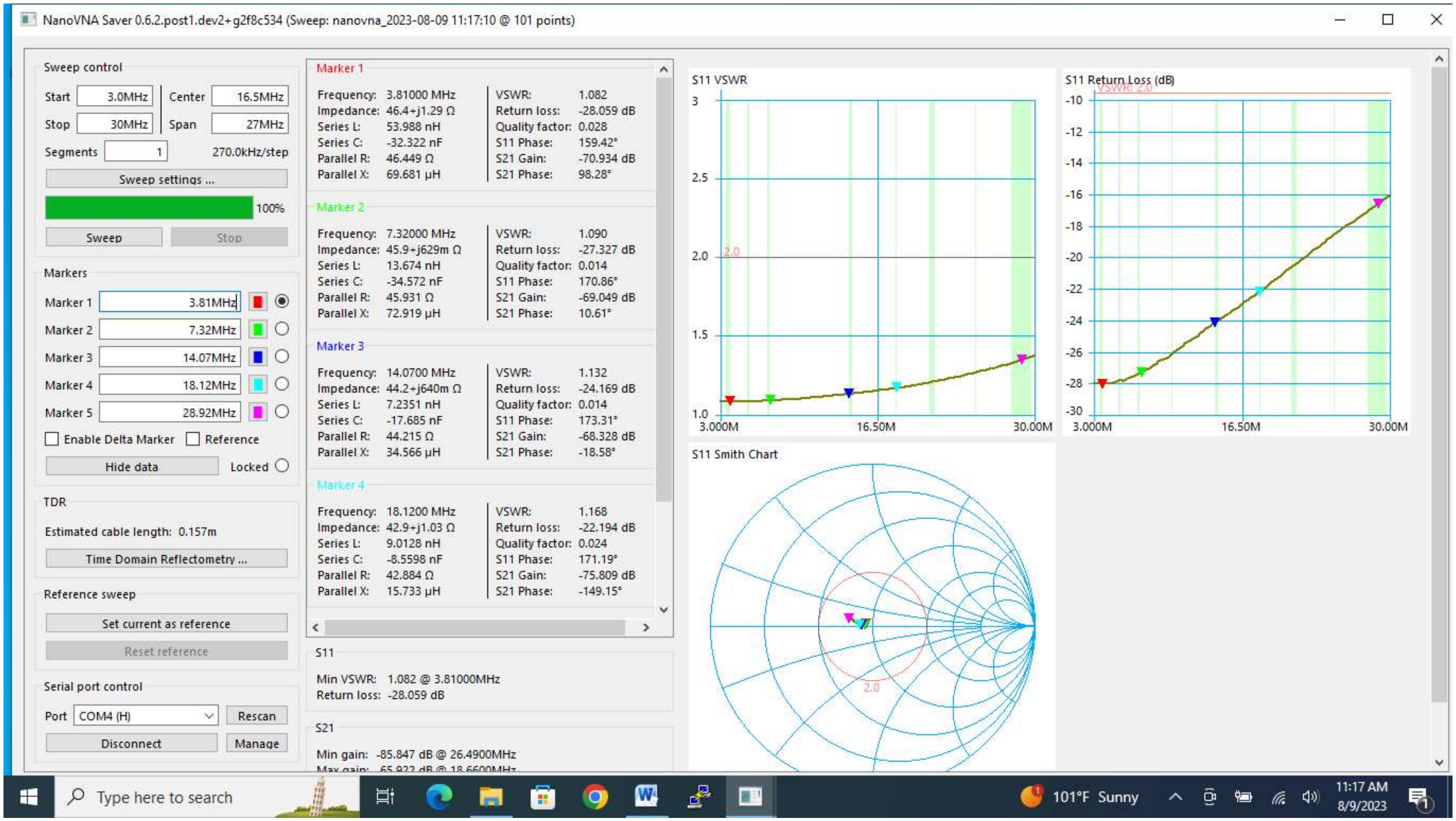
Random Wire Antenna scan with Ferrite (TF140-43) 9:1 UnUn



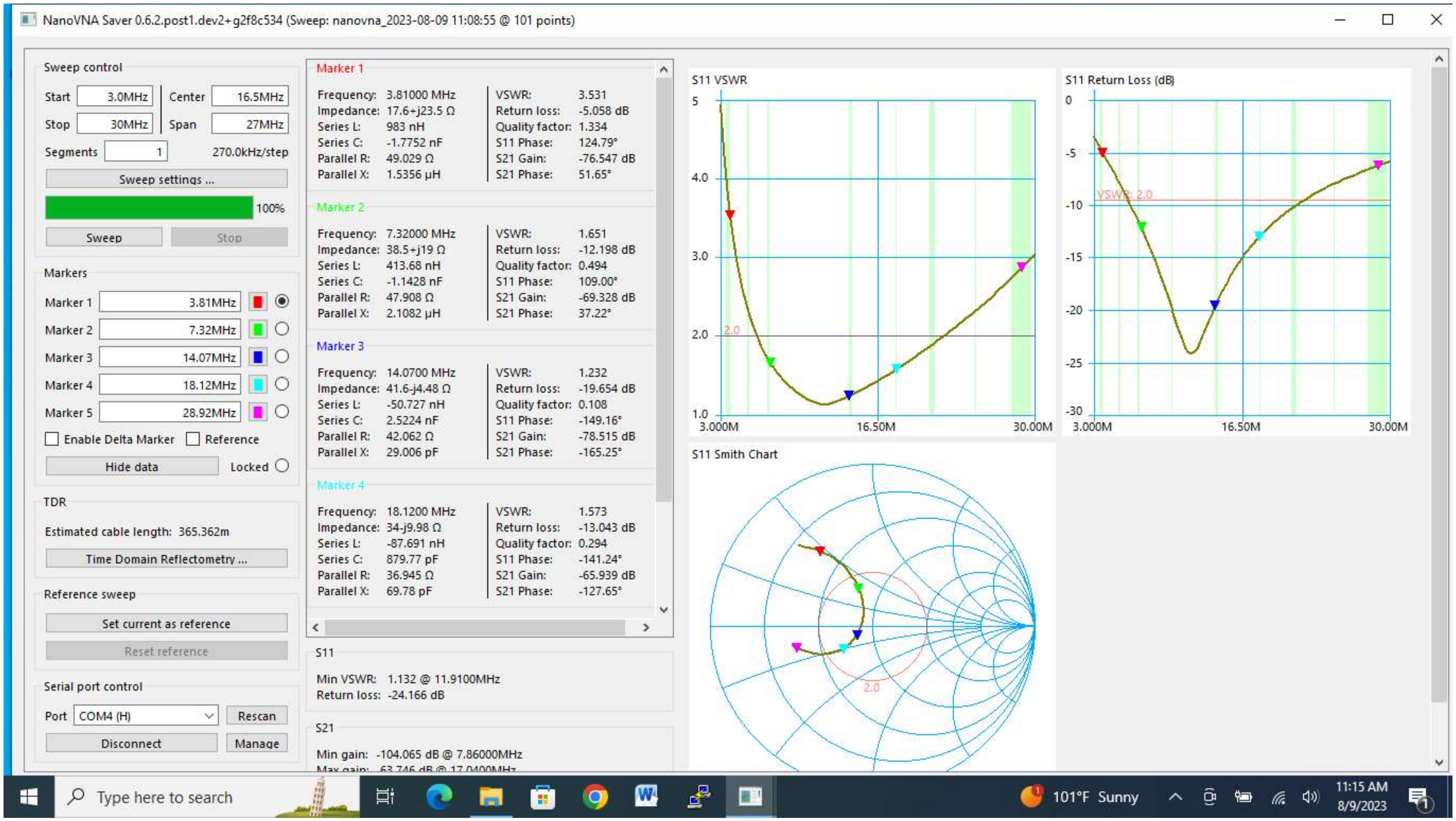
Random Wire Antenna scan with Powder Core (T200-2) 9:1 UnUn



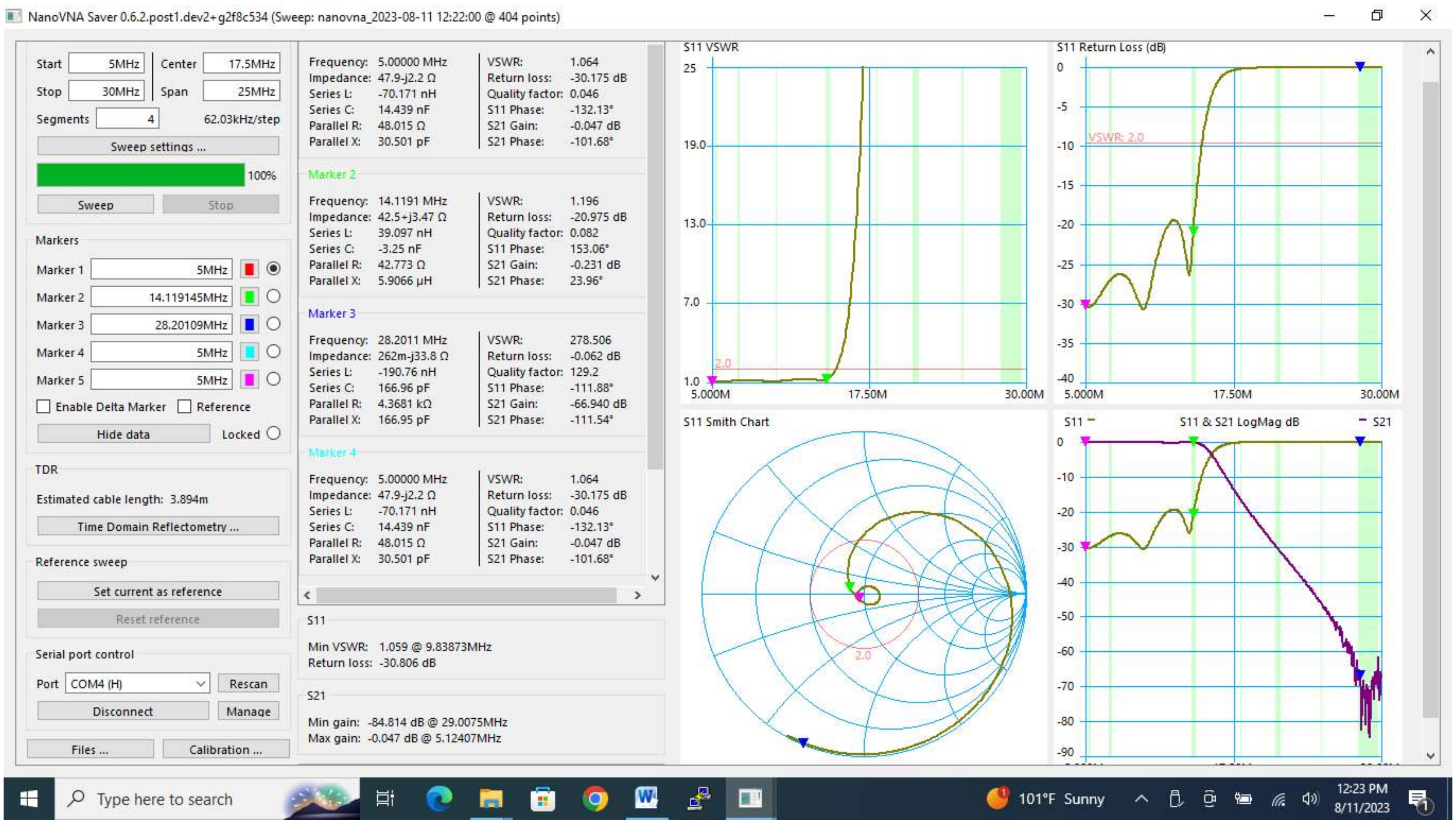
UnUn scan of Ferrite (TF140-43) 9:1 UnUn with 440 Ohm Load



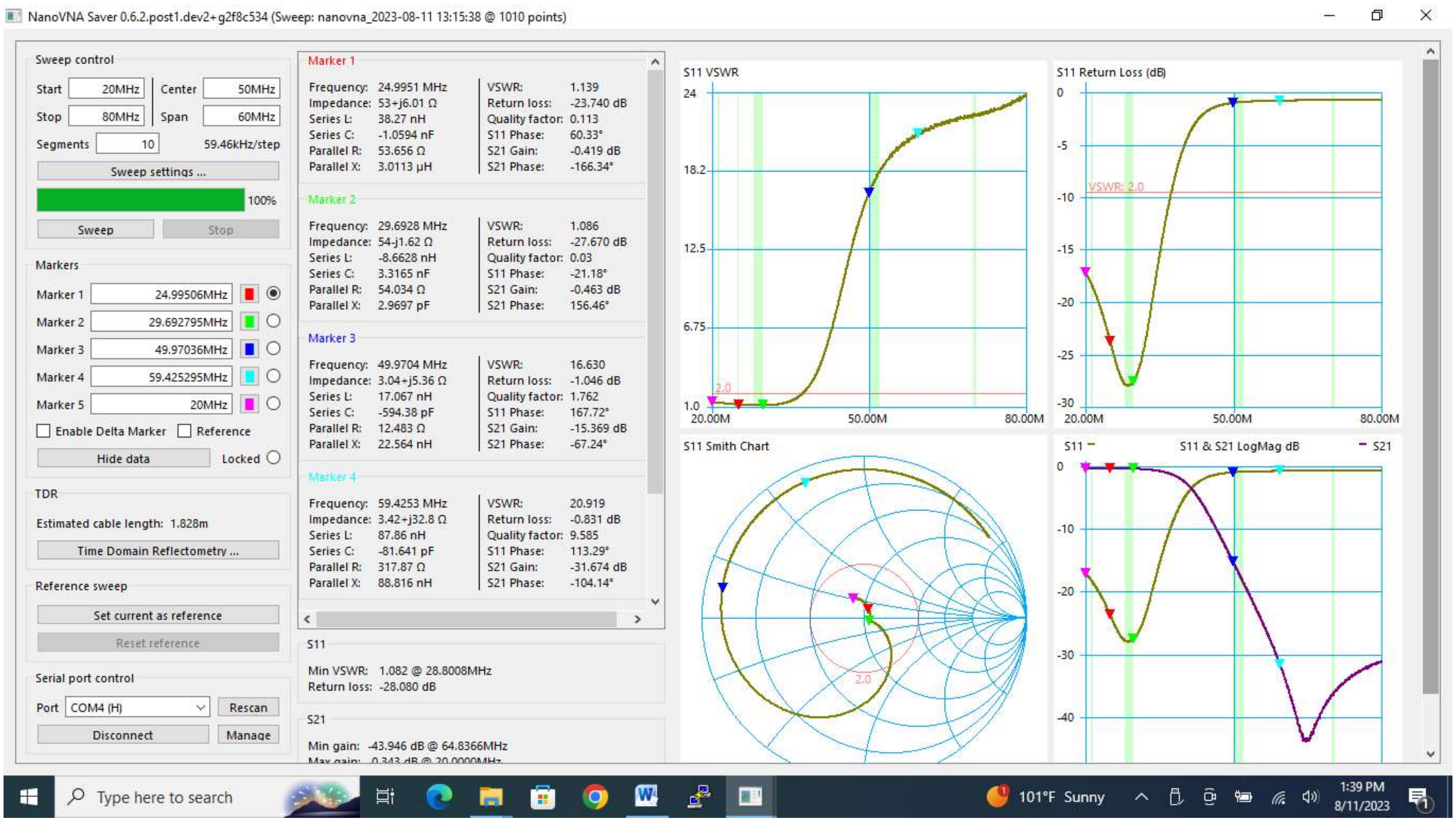
UnUn scan of Powder Core (T200-2) 9:1 UnUn with 440 Ohm Load



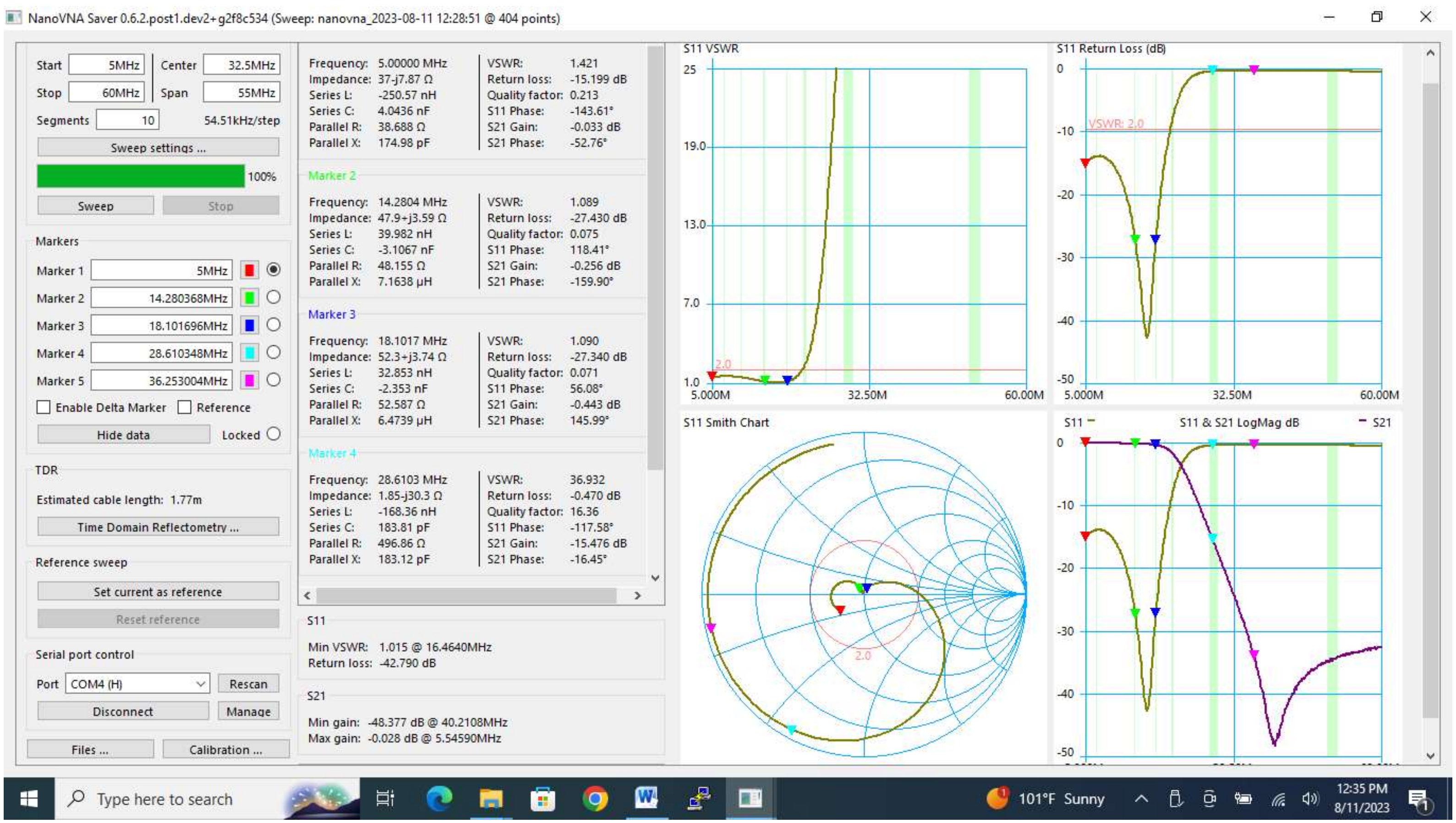
20m 7-element Chebyshev low pass filter



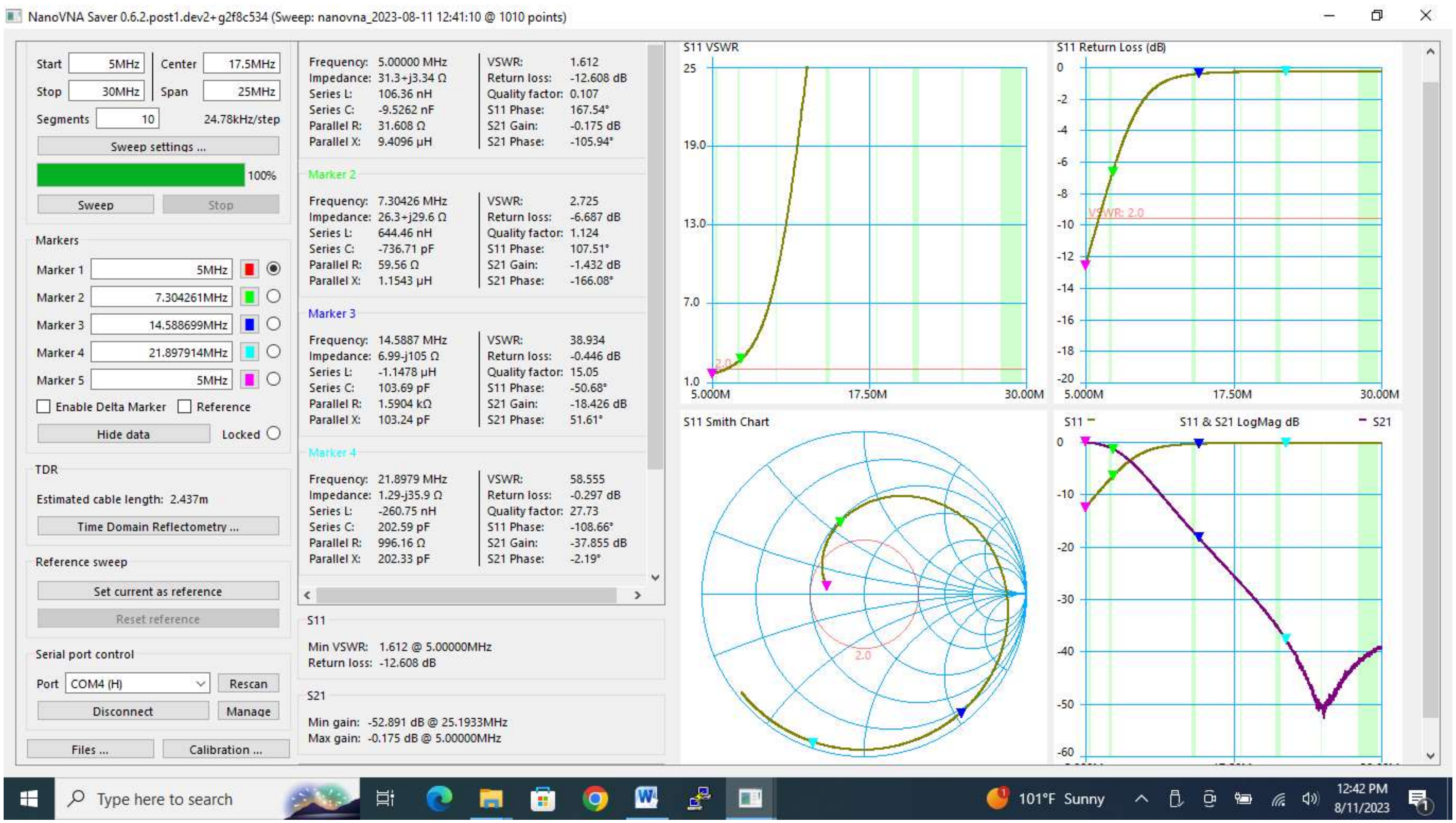
10m-12m 5-element multiband Chebyshev low pass filter



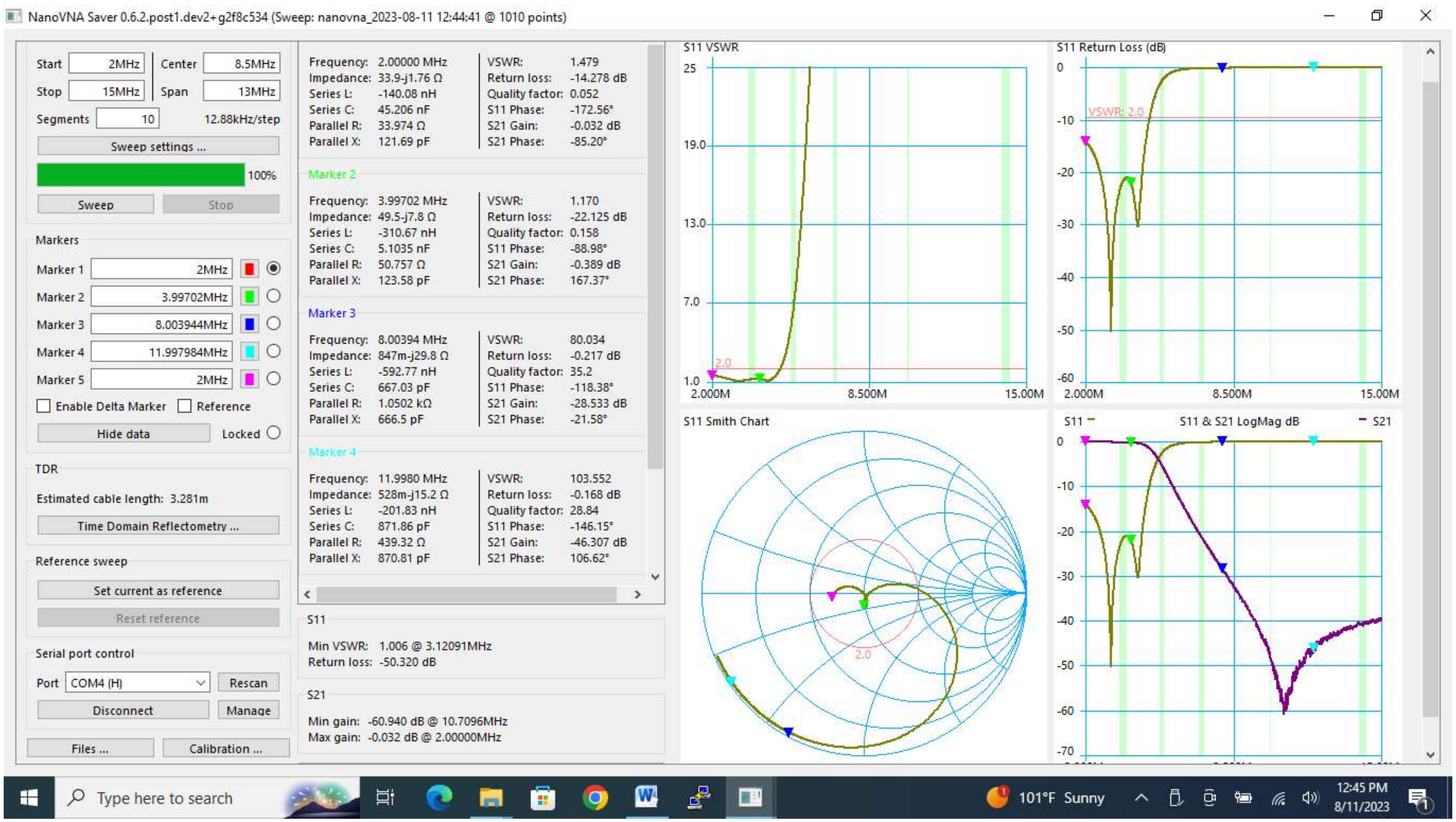
20m-17m 5-element multiband Chebyshev low pass filter



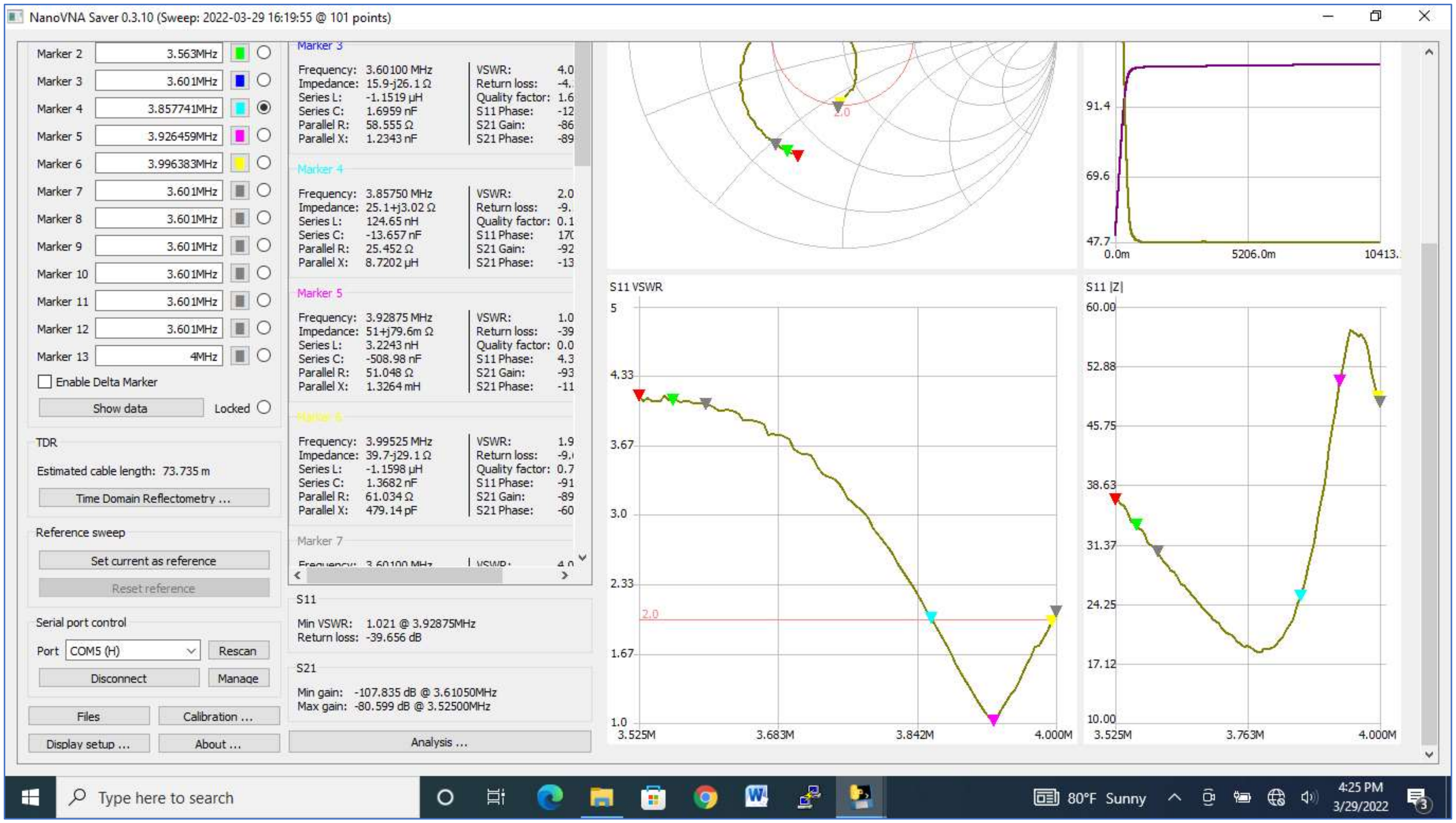
40m 5-element multiband Chebyshev low pass filter



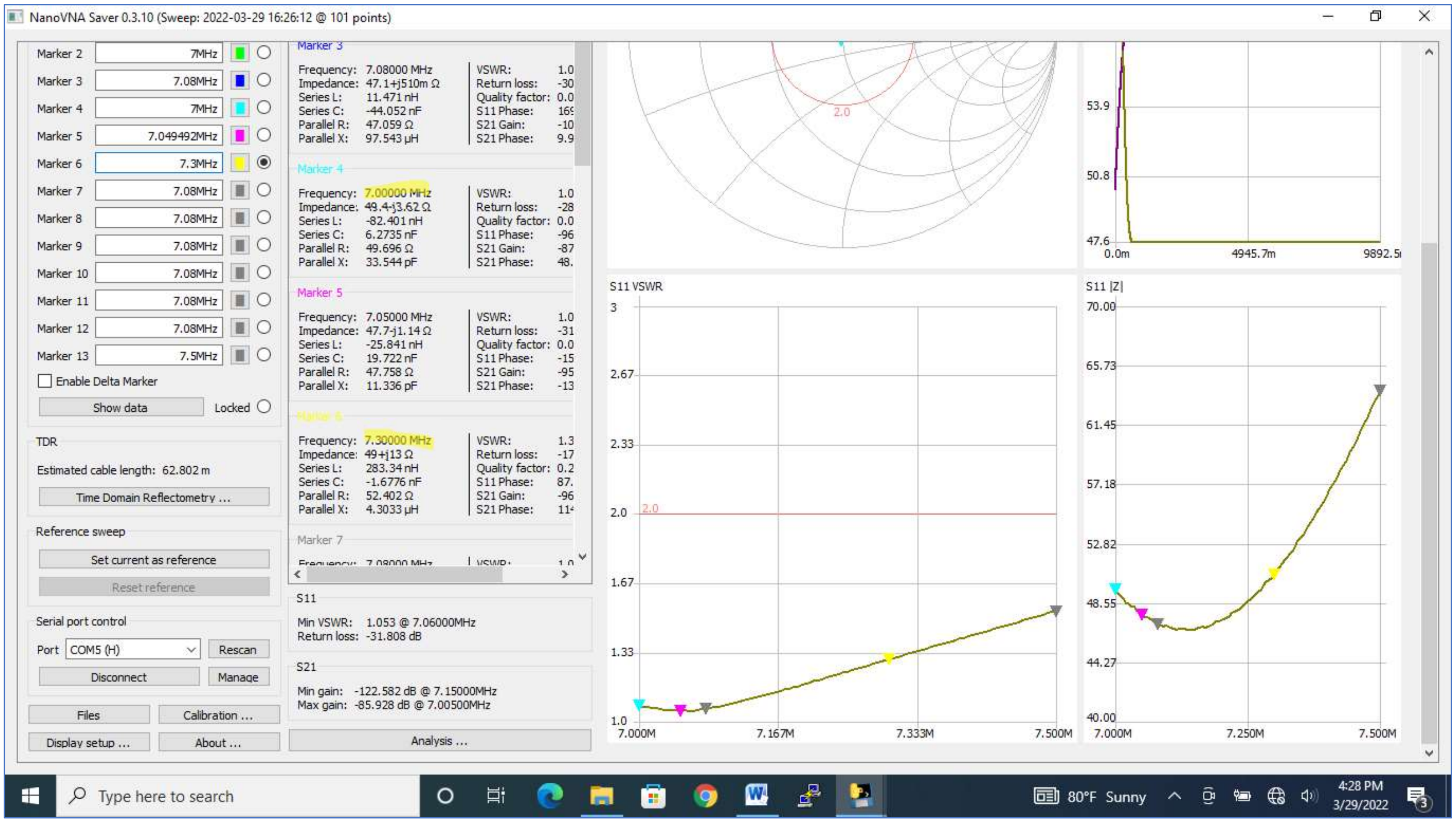
80m 5-element multiband Chebyshev low pass filter



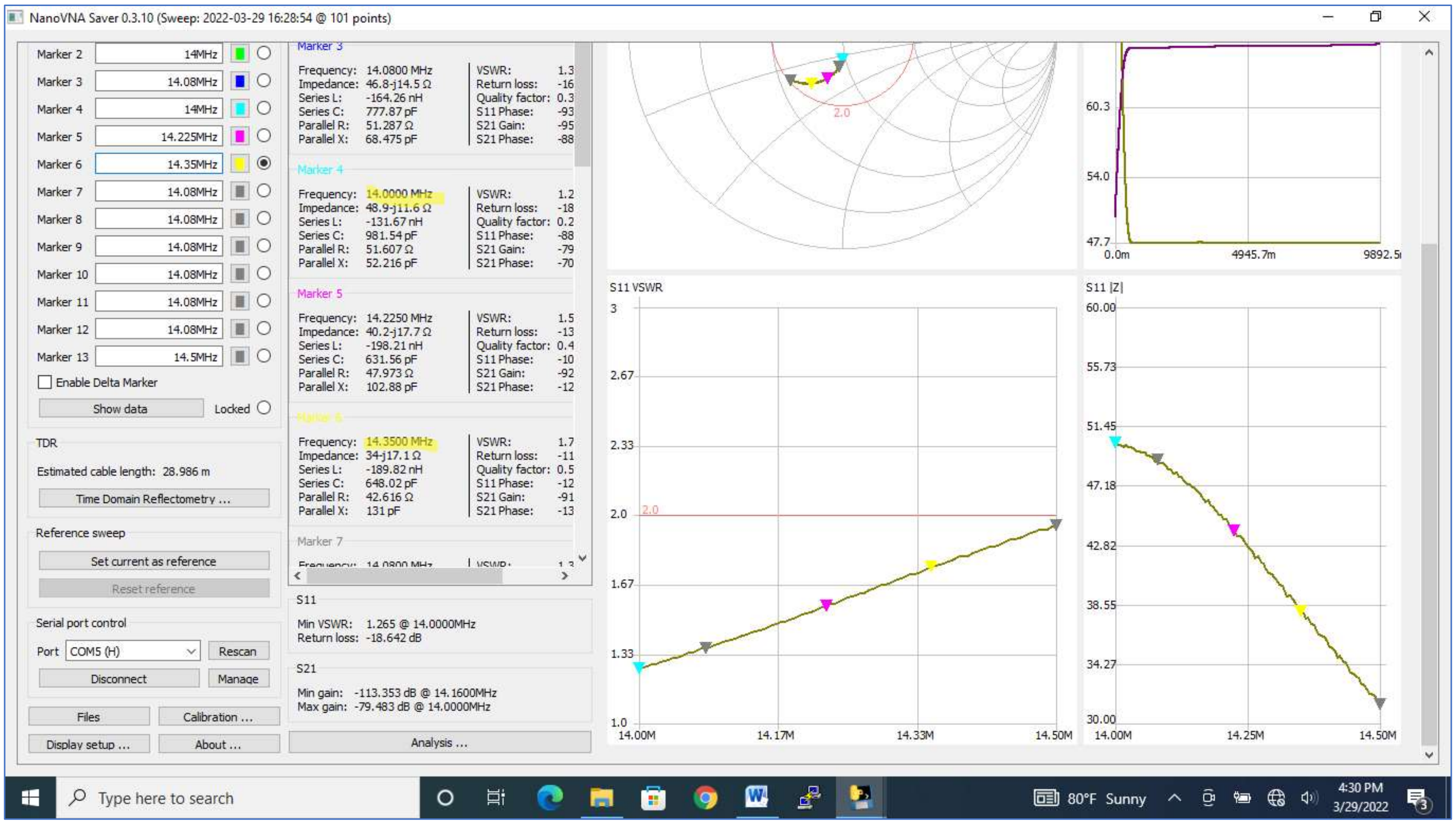
80 m scan of 250W ARRL (HFKits) EFHW Antenna Kit I built and deployed with a self-wound trap at a little over 20 meters in length, followed by about 2.5 meters behind the trap.



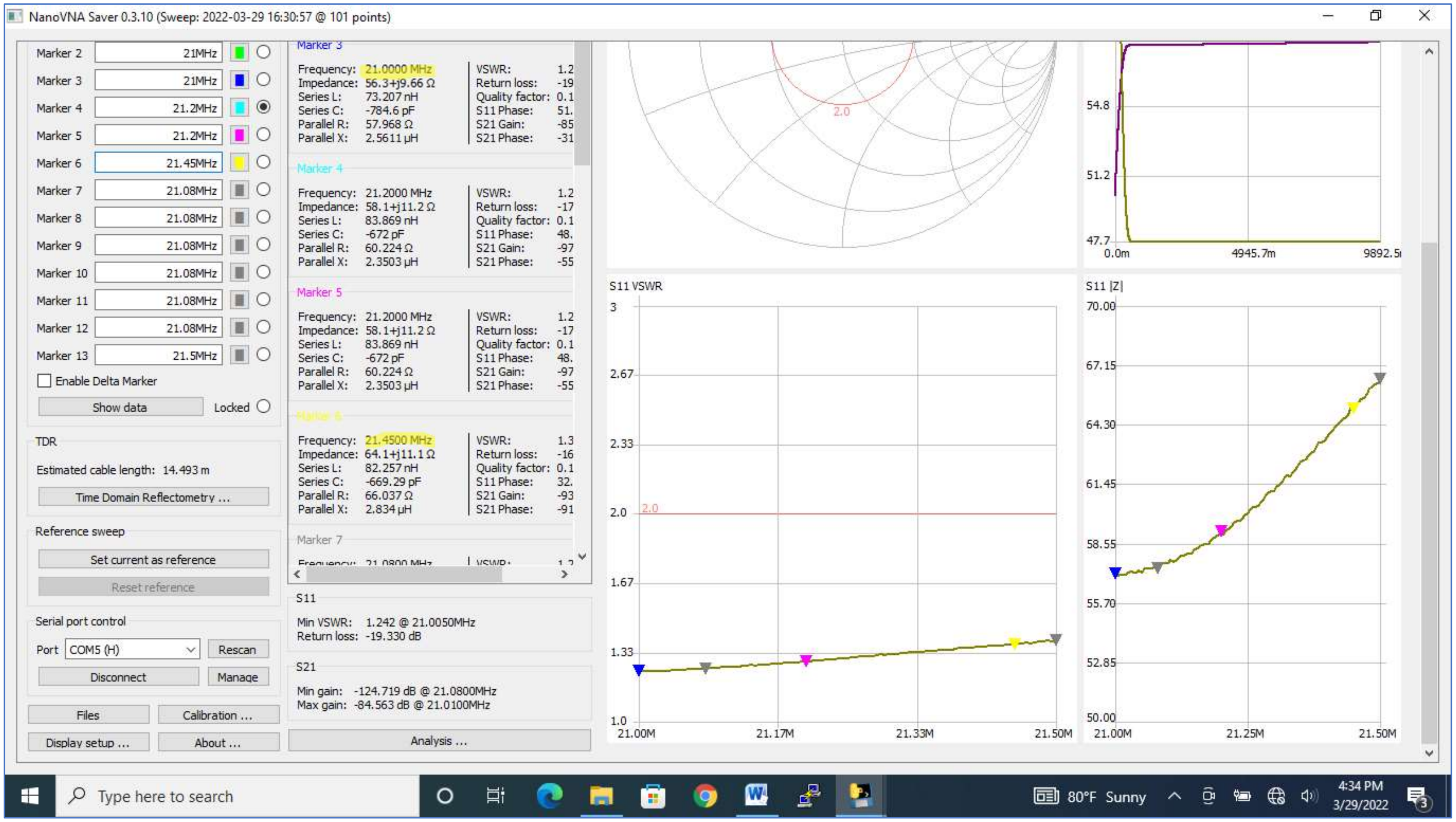
40 m scan of 250W ARRL (HFKits) EFHW Antenna Kit I built and deployed with a self-wound trap at a little over 20 meters in length, followed by about 2.5 meters behind the trap.



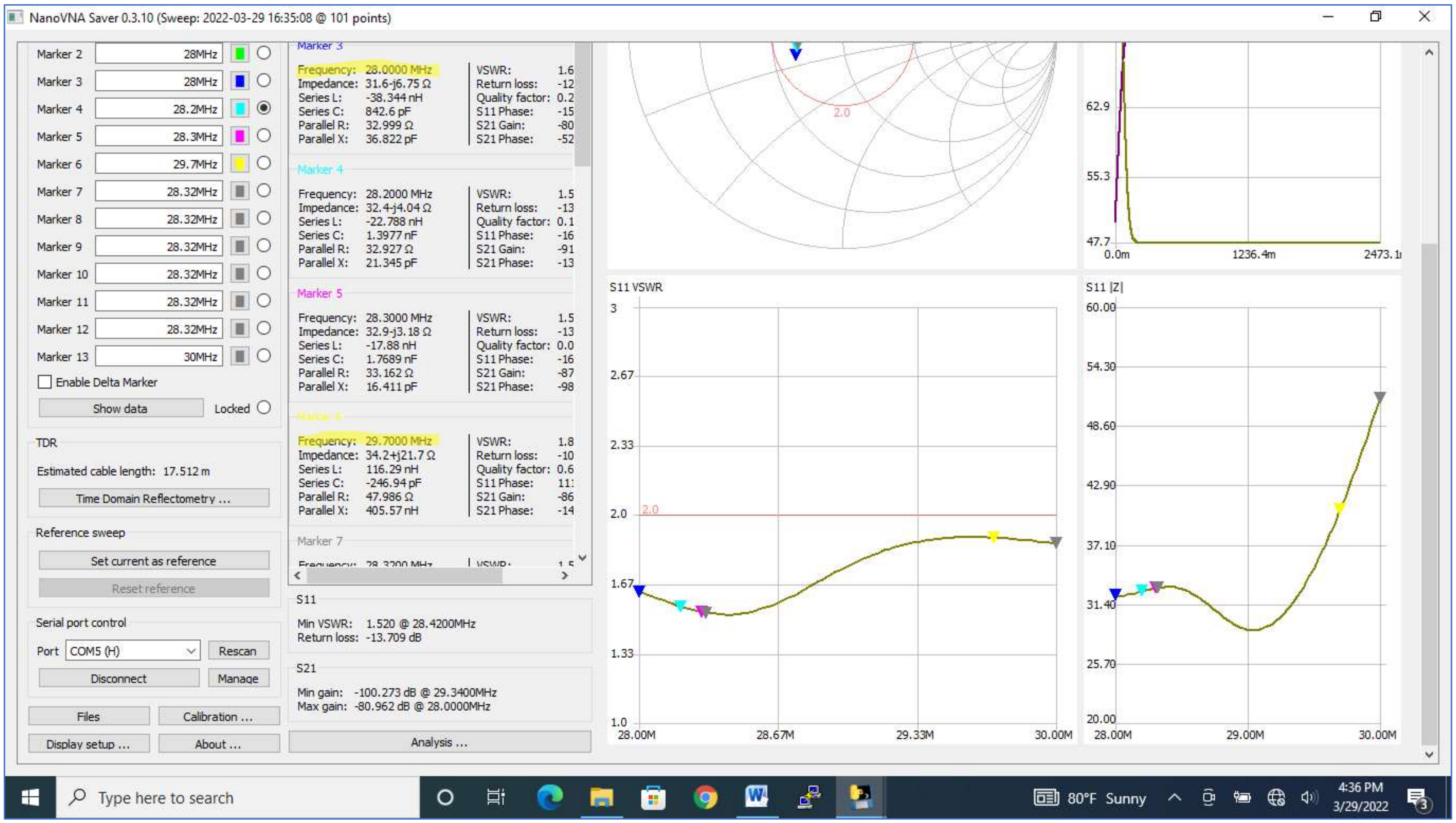
20 m scan of 250W ARRL (HFKits) EFHW Antenna Kit I built and deployed with a self-wound trap at a little over 20 meters in length, followed by about 2.5 meters behind the trap.



15 m scan of 250W ARRL (HFKits) EFHW Antenna Kit I built and deployed with a self-wound trap at a little over 20 meters in length, followed by about 2.5 meters behind the trap.



10 m scan of 250W ARRL (HFKits) EFHW Antenna Kit I built and deployed with a self-wound trap at a little over 20 meters in length, followed by about 2.5 meters behind the trap.



NanoVNA Waveform showing the 14.3 MHz output waveform of the nanoVNA and a sample scan